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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 2, 2016/2017

### THP7021 – HIGH PERFORMANCE COMPUTING AND BIG DATA

( All sections / Groups )

10<sup>th</sup> FEBRUARY 2017  
8.00 p.m - 10.00 p.m  
( 2 Hours )

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#### INSTRUCTIONS TO STUDENT

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL FOUR (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

**Question 1 [10 marks]**

Given this serial programme:

```
double f(double x); // A very computation-intensive
function.
// Assume that START, END and the function f are defined
// somewhere.

int main(int argc, char *argv[])
{ double total = 0, x;
  int partitions;
  double slice;

  printf("How many partitions? "); fflush(stdout);
  scanf("%d", &partitions);
  slice = (END-START)/partitions;
  for (x = START + (slice/2); x < END; x = x + slice)
    total = total + f(x);
  total = total * slice;

  printf("The integration is %1.20f\n", total);
}
```

We have covered several ways to do parallel processing – MPI, OpenMP, Pthreads, and Hadoop.

- a) What kind of situation would it be better to convert this program into an MPI program, as opposed the other ways we covered? Explain why this is the best choice in the situation you described, and why each of the other three are not suitable. [5 marks]
- b) What kind of situation would it be better to convert this program into an openMP program, as opposed the other ways we covered? Explain why this is the best choice in the situation you described and why each of the other three are not suitable. [5 marks]

Continued...

**Question 2 [10 marks]**

Convert the serial program from question 1 into an OpenMP programme. [10 marks]

**OpenMP quick reference***Constructs*

**#pragma omp parallel for** [shared(vars),  
private(vars), firstprivate(vars),  
lastprivate(vars), default(shared|none),  
reduction(op:vars), copyin(vars), if(expr),  
ordered, schedule(type[,chunkSize])]

**#pragma omp parallel sections**  
[shared(vars), private(vars),  
firstprivate(vars), lastprivate(vars),  
default(shared|none), reduction(op:vars),  
copyin(vars), if(expr)]

**#pragma omp parallel** [shared(vars),  
private(vars), firstprivate(vars),  
lastprivate(vars),  
default(private|shared|none),  
reduction(op:vars), copyin(vars), if(expr)]

*Directives*

**shared(vars)**  
**private(vars)**  
**firstprivate(vars)**  
**lastprivate(vars)**  
**default(private|shared|none)**  
**reduction(op:vars)**  
**copyin(vars)**  
**if(expr)**  
**schedule(type[,chunkSize])**  
**nowait**

*Synchronization/Locking Constructs*

**#pragma omp master**  
**#pragma omp critical**  
**#pragma omp barrier**  
**#pragma omp atomic**  
**#pragma omp flush[(vars)]**

*Settings and Control*

**int omp\_get\_num\_threads()**  
**int omp\_get\_thread\_num()**  
**int omp\_in\_parallel()**  
**int omp\_get\_max\_threads()**  
**int omp\_get\_num\_procs()**  
**int omp\_get\_dynamic()**  
**int omp\_get\_nested()**  
**double omp\_get\_wtime()**  
**double omp\_get\_wtick()**  
**void omp\_set\_dynamic(int)**  
**void omp\_set\_nested(int)**

*Environment Variables*

**OMP\_NUM\_THREADS**  
**OMP\_SCHEDULE**

Continued...

**Question 3 [10 marks]**

Convert the serial program from question 1 into an MPI programme.

[10 marks]

**MPI Quick Reference***Environmental Management:*

```

int MPI_Init(int *argc, char **argv[])
int MPI_Finalize(void)
int MPI_Initialized(int *flag)
int MPI_Finalized(int *flag)
int MPI_Comm_size(MPI_Comm comm, int *size)
int MPI_Comm_rank(MPI_Comm comm, int *rank)
int MPI_Abort(MPI_Comm comm, int errorcode)
double MPI_Wtime(void)
double MPI_Wtick(void)

```

*Blocking Point-to-Point-Communication:*

```

int MPI_Send (void* buf, int count, MPI_Datatype datatype, int dest, int tag, MPI_Comm comm)
int MPI_Recv (void* buf, int count, MPI_Datatype datatype, int source, int tag, MPI_Comm comm, MPI_Status *status)
int MPI_Probe (int source, int tag, MPI_Comm comm, MPI_Status *status)
int MPI_Get_count (MPI_Status *status, MPI_Datatype datatype, int *count)
int MPI_Sendrecv(void *sendbuf, int sendcount, MPI_Datatype sendtype, int dest, int sendtag, void *recvbuf, int recvcount, MPI_Datatype recvtype, int source, int recvtag, MPI_Comm comm, MPI_Status *status)
int MPI_Sendrecv_replace(void *buf, int count, MPI_Datatype datatype, int dest, int sendtag, int source, int recvtag, MPI_Comm comm, MPI_Status *status)

```

*Collective Communication:*

```

int MPI_Barrier (MPI_Comm comm)
int MPI_Bcast (void *buffer, int count, MPI_Datatype datatype, int root, MPI_Comm comm)
int MPI_Gather (void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm)
int MPI_Gatherv (void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount_array[], int displ_array[], MPI_Datatype recvtype, int root, MPI_Comm comm)
int MPI_Scatter (void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int

```

```

recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm)
int MPI_Scatterv (void *sendbuf, int sendcount_array[], int displ_array[], MPI_Datatype sendtype, void *recvbuf, int recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm)
int MPI_Allgather (void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount, MPI_Datatype recvtype, MPI_Comm comm)
int MPI_Allgatherv (void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount_array[], int displ_array[], MPI_Datatype recvtype, MPI_Comm comm)
int MPI_Reduce (void *sendbuf, void *recvbuf, int count, MPI_Datatype datatype, MPI_Op op, int root, MPI_Comm comm)
int MPI_Allreduce (void *sendbuf, void *recvbuf, int count, MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
int MPI_Reduce_scatter (void *sendbuf, void *recvbuf, int recvcount_array[], MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
int MPI_Op_create (MPI_User_function *func, int commute, MPI_Op *op)
int MPI_Op_free (MPI_Op *op)

```

*Wildcards:*

MPI\_ANY\_TAG, MPI\_ANY\_SOURCE

*Basic Datatypes:*

```

MPI_CHAR, MPI_SHORT, MPI_INT, MPI_LONG, MPI_UNSIGNED_CHAR, MPI_UNSIGNED_SHORT, MPI_UNSIGNED_LONG, MPI_FLOAT, MPI_DOUBLE, MPI_LONG_DOUBLE, MPI_BYTE, MPI_PACKED

```

*Predefined Groups and Communicators:*

```

MPI_GROUP_EMPTY, MPI_GROUP_NULL, MPI_COMM_WORLD, MPI_COMM_SELF, MPI_COMM_NULL

```

*Reduction Operations:*

```

MPI_MAX, MPI_MIN, MPI_SUM, MPI_PROD, MPI_BAND, MPI_BOR, MPI_BXOR, MPI_LAND, MPI_LOR, MPI_LXOR

```

**Question 4 [10 marks]**

- a) In Hadoop, what is map? [2 marks]
- b) In Hadoop, what is reduce? [2 marks]
- c) You have a server farm that has millions of web pages. You need to figure out which are the top ten most popular web pages. How would you do this with Hadoop? (The answer is only expected to be a few sentences – you do not have to write an essay.) [6 marks]